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UNCLAS SECTION 01 OF 08 NEW DELHI 002641

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TAGS: ENRG TRGY SENV KGHG TSPL TNGD EIND KSCA ECON
SUBJECT: WITH THE UPCOMING LAUNCH OF "CHANDRAYAAN I" MOON MISSION, INDIA AIMS TO BE A GLOBAL PLAYER IN SPACE

REF A :NEW DELHI 1257
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¶1. (U) Summary. The Indian Space Research Organization (ISRO) is poised to take on many ambitious projects with the aim of establishing broader international collaborations, developing novel technologies to meet social and economic development needs, and attracting and harnessing India's young talent in science and technology. India tripled its space program budget to USD 10 billion for the Eleventh Five-Year Plan period (2007-2012), which includes funding for two moon missions. Scheduled for an October 22 launch, "Chandrayaan I" will be a two-year-long mission consisting of eleven experiments to map and study resources on the moon's surface. NASA developed two of the experiments, and is also exploring future collaborations with ISRO. Antrix, ISRO's commercial arm, grew 20 percent last year and facilitated ISRO's launch of satellites for several countries. ISRO's future plans include developing nano and pico satellites, launching satellites to study astronomy, the Sun, and Mars, and conducting a manned moon mission. Import restrictions because of sanctions and a lack of qualified scientists and engineers are ISRO's key challenges. End Summary. End Summary.

## Space Program, One of the Successful Indian Science and Technology Missions

¶2. (U) The Indian space program which originated with India's

participation in a US led international program for tracking satellites in the early 60s, has come a long way with over 18 institutions under its fold. Today India believes that it has complete indigenous technological capability for development of satellites and rockets and to launch them to meet its social and economic development aspirations. The only area where ISRO feels it needs new technology development is semiconductor fabrication for fabrication of microchips to develop the associated electronic systems. With a view to further enhance the activities and capabilities of ISRO, the Eleventh Five-Year Plan (2007-2012) has an outlay of USD 10.5 billion (INR 450 billion) for space research, which is more than three times the allocation of USD 3 billion (INR 132.5 billion) during the Tenth Plan period (2001-2006).

¶3. (U) ISRO has several mission goals. First and foremost, India expects space technology to be a key tool or enabler for social and economic development including Information and Communication Technology (ICT), weather forecasting, natural and agricultural resource monitoring, environment monitoring, e-learning, telemedicine and security. It also aspires to be at the cutting edge of technology and collaborate with advanced nations in joint scientific experiments in space. Another key goal of the "Chandrayaan" (moon) mission program is to help motivate and attract a large number of youth into science and technology research and reinvigorate the scientific activity in the country. The key features of India's indigenous space program are:

The Indian National Satellite (INSAT) system includes eleven communication and broadcast satellites with over 210 transponders and supports Direct to Home (DTH) services and meteorological data.

The Indian Remote Sensing (IRS) Satellite System includes eight imagery satellites - one of the largest civilian constellations in



the world - that provide imagery in a variety of spatial resolutions and spectral bands.

The Polar Satellite Launch Vehicle (PSLV) with 13 successful launches can launch payloads of up to 1000kg in a polar synchronous orbit.

The Geosynchronous Satellite Launch Vehicle (GSLV) with four out of five successful launches can launch 2000 to 2500kg payloads into a geosynchronous orbit.

¶4. (U) The repeated successes of these systems have been the basis for India to take up a challenging project such as the "Chandrayaan" (moon) mission and investigate the feasibility of mission to Mars and beyond. In addition, the opening of space and the defense sectors to private participation has made India an attractive destination for investments in aerospace industries.

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"Chandrayaan I" Mission Objectives, Key Features and the Launch
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¶5. (U). "Chandrayaan-I", India's first scientific mission to the moon, aims to expand the understanding of its origin and evolution, study the moon's surface for resources, upgrade India's technological capabilities, and provide opportunities to the young scientists working in planetary sciences. The unmanned mission will involve eleven experiments over a period of two years - six of those from other countries including the USA, the UK, Germany, Sweden, Bulgaria and Japan. The payloads have been integrated into the spacecraft, and the system subjected to environmental tests including thermo-vacuum tests (rapid heating and cooling cycle tests with temperature varying from +120 C to -150 C), vibration and noise tests. SciCouns had visited the ISRO facility in Bangalore in July and observed the integration process of the two US instruments on the spacecraft and had discussions with Dr.Annadurai, Project Director "Chandrayaan I" about the preparations. The complete system is expected to be docked on to the launch vehicle by October 12 or 13 at Sriharikota in Andhra Pradesh. As of the now the launch date could be between October 20 and 22, weather permitting. The

project cost is estimated at USD 89 million (INR 3.86 billion) - not including partner country instruments.

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Launch Process
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¶6. (U) The spacecraft, weighing about 1050kg, will be launched by PSLV into an elliptical parking orbit of 240km perigee and 36,000km apogee - very similar to a geosynchronous transfer orbit. The spacecraft will then use its own liquid apogee motor to take it to a trans-lunar injection orbit, and finally for lunar orbit insertion. In its final orbit of 100km above the moon, the spacecraft will weigh 525kg including the liquid fuel and micro thrusters required for a 2-year life span. The journey from the earth to the moon should take five and half days.

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Tracking of the Launch and Receiving Data
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¶7. (U) A new 32-meter antenna - built jointly by Electronics Corporation of India Limited (ECIL) Hyderabad, Bhabha Atomic Research Center(BARC) Mumbai, and various ISRO labs and private Indian industries - is operational at the Indian Deep Space Network



(IDSN) center in Byalalu, near Bangalore to monitor the launch and receive data from the moon. The antenna is capable of capturing and receiving signals from a distance of over 400,000km in outer space and can be moved at a lower speed of 0.01 millidegrees per second, an upper speed of 0.4 millidegrees per second with a vertical maneuverability of 90 degrees and capacity to rotate over 270 degrees. India will also track the launch with an 18-metre antenna installed in 2006 which can receive signals from up to 100,000km. ISRO Telemetry, Tracking and Command Network (ISTRAC) will manage the tracking activity.

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Moon Mission Experiments
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¶8. (U) The eleven experiments to be carried out under the "Chandrayaan-I" mission are essentially geared to map the moon's surface for minerals and chemicals, to provide clues to the origin of the moon and explore the dark side of the moon for traces of water, especially in the large lunar craters that receive no sunlight and hence may contain frozen water. Another key element Indian scientists hope to locate is Helium-3. If detected, it could be extremely useful in nuclear reactors if transported to the earth. The following instruments are part of this mission:

-Terrain Mapping Stereo Camera (TMC) developed by ISRO to produce a high-resolution 3-dimensional atlas or a high resolution map of both the near and the far side of the moon to understand the evolution process and to identify regions of future scientific interests. The TMC has a spatial/ground resolution of 5m and swath coverage of 20km.
-Hyper Spectral Imager (HySI) developed by ISRO is for mineralogical mapping in the visible and near infrared region (400-950 nm) with a spectral resolution of 15nm, a spatial resolution of 80m and swath coverage of 20km.
-Lunar Laser Ranging Instrument (LLRI) developed by ISRO to illuminate the terrain with a laser pulse and accurately estimate the altitude of the spacecraft above the lunar surface and determine the global topographical field of the moon. These data along with the TMC information is expected to be used to obtain an improved lunar gravity model.
-High Energy X-ray (HEX) developed by ISRO is to be used to detect X-rays emitted in the energy region of 30-250keV using a Cadmium-Zinc-Telluride (CdZnTe) detector array, with a field of view of 40km X 40km.
-Moon Impact Probe (MIP) developed by ISRO is expected to piggy back on the "Chandrayaan I" and is to be released to drop on to the surface of the moon at a desired location once the space craft reaches a distance of 100km from the moon. The MIP is expected to be a proof of concept of technologies required for an impact probe at a desired location on the moon and also qualify technologies required for future soft landing missions on the surface of the

moon.
-Chandrayaan-I X-ray Spectrometer (C1XS) is a joint effort between Rutherford Appleton Laboratory, UK and ISRO Satellite Centre through the European Space Agency (ESA), will use X-ray fluorescence technique (1 -10keV) to map the moon, focused on understanding its origin and evolution and measuring the elemental abundance of Mg, Al, Si, Ca, Fe and Ti.
-Near Infra Red spectrometer (SIR-2) developed by the Max-Plank Institute for Solar System Science, Germany is expected to be the key instrument for identifying the chemical composition of the crust and mantle of the moon. It is also expected to help understand the "space weathering" process of the surface of the moon and identify



future landing spots.
-Sub keV Atom Reflecting Analyser (SARA) was developed jointly by Swedish Institute of Space Physics, Sweden and Space Physics Laboratory, Vikram Sarabhai Space Centre, ISRO through ESA. SARA will be used to image the moon's surface using low energy neutral atoms (10eV-2keV) to get further information on its surface composition, to study solar wind surface interactions and the result of weathering of the moon surface due to bombardment by solar wind ions.
-Radiation Dose Monitor Experiment (RADOM) developed by the Bulgarian Academy of Sciences, Bulgaria will be used to qualitatively and quantitatively characterize, in terms of particle flux, dose rate and deposited energy spectrum and the radiation environment at different altitudes from the moon's surface.
-Moon Mineralogy Mapper (M3) jointly developed by Brown University and Jet Propulsion Laboratory, USA through NASA is to be used to characterize and map lunar surface mineralogy with referfnce to the geologic evolution of Moon. This essentially involves understanding the highland crust, basaltic volcanism, impact craters and potential volatiles on the moon's surface. The M3 is a high throughput imaging spectrometer operating in spectral range from 0.7 micron to 3.0 micron range, with a spectral resolution of 10nm, spatial resolution of 70 m/pixel and a field of view of 40km [from 100km orbit]. It measures solar reflected energy using a two-dimensional Mercury Cadmium Telluride detector array.
-Miniature Synthetic Aperture Radar (MiniSAR) developed by the Applied Physics Laboratory, Johns Hopkins University and Naval Air Warfare Centre, USA through NASA is to be used for the detection of water (ice) in the permanently shadowed regions on the moon up to a depth of a few meters. The synthetic aperture radar system works at a frequency 2.38 GHz with a resolution of 75m per pixel.

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"Chandrayaan II" Program
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¶9. (SBU) At present, India plans to carry out two moon missions. It has already approved a budget of USD 98.9 million (INR 4.25 billion) for the "Chandrayaan-II" mission which is expected to take place around 2011-12. The key objective of the mission is to land a motorized rover on the moon to collect soil and rock samples and perform further chemical analysis of the lunar surface. Russia has signed up, as one of the first partners for the mission, to develop the Lander/Rover system. ISRO will be developing the Orbiter system. Scientific instruments and experiments from other countries may also be accommodated. NASA has had some dialogue regarding US participation and is considering sending an advanced Radioisotope Thermoelectric Generator (RTG) power source (generates power from a 238 Plutonium heat source) aboard "Chandrayaan II". This could be mission enabling/enhancing for "Chandrayaan II". Because the advanced RTG has moving parts, NASA is seeking a flight opportunity to qualify it prior to its use on long duration outer planetary missions. India has also recently joined eight nations (US, Canada, Germany, Italy, Japan, South Korea, France and England) to develop new technologies for exploratory robotic manned missions to the moon. ISRO intends to launch the "Chandrayaan-II" using GSLV, and plans additional GSLV trial launches using the indigenously developed cryogenic engines before the mission in 2011-12.

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Indigenous Cryogenic Upper Stage (CUS) for GSLV
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¶10. (U) The CUS is the key to ISRO's ambitions to enhance its

capabilities to launch heavier payloads. Restrictions on acquiring



these engines and related technologies led ISRO to embark on indigenous development of the CUS, which was successfully tested for full flight duration of 720 seconds on November 15, 2007 at the Liquid Propulsion test facility at Mahendragiri in Tamil Nadu. With this test, ISRO considers the CUS qualified for the next GSLV launch. The CUS is powered by a regeneratively cooled cryogenic engine, a key component, which works on staged combustion cycle (multistage burning of the propellant for enhanced efficiency) developing a thrust of 69.5kN in vacuum. Liquid Oxygen (LOX) and Liquid Hydrogen (LH2) from the respective tanks are fed by individual booster pumps to the main turbo-pump rotating at 39,000 rpm to ensure a high flow rate of 16.5 kg/sec of propellants into the combustion chamber. The main turbine is driven by the hot gas produced in a pre-burner. Thrust control and mixture ratio control are achieved by two independent regulators. The various materials and the diverse sub-systems associated with the CUS were developed by Liquid Propulsion Systems Centre (LPSC) Bangalore (the lead lab) along with Vikram Sarabhai Space Centre (VSSC), other ISRO centers and several industries, both in the public and private sectors.

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ISRO Enabled Development Programs
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¶11. (U) The INSAT series of eleven satellites and the IRS series of eight satellites have enabled a wide range of social and economic development activities in India. The INSAT System is one of the largest domestic communication satellite systems in the Asia Pacific region, supporting over 210 transponders and 65,000 Very Small Aperture Terminals (VSAT). The system has enabled the expansion of television coverage to more than 40 Doordarshan (public) channels and 50 private TV channels, and rapid expansion of DTH (Direct to Home) television services. ISRO expects to increase to 500 transponders in the next four to five years.

¶12. (U) The Education Satellite (EDUSAT), dedicated exclusively for educational services, was launched in September 2004 and provides one-way TV broadcast, interactive TV, video conferencing and web-based instructions for education. About 46 networks in 23 states connect more than 2,500 interactive and about 31,000 receive-only nodes at schools, colleges, training institutes and other GOI agencies. At the recent Faculty Leadership Institute (FLI) organized at the Infosys Training Center in Mysore, jointly by the Indo US Collaboration on Engineering Education (IUCEE) and American Society of Engineering Education (ASEE) to educate the faculty in the area of ICT, lectures were beamed live to over 50 colleges across India. SciCouns was involved in facilitating this program, where 30 faculty from several US universities conducted training courses for 600 faculty from India.

¶13. (U) Telemedicine is another key initiative facilitated by ISRO. ISRO is driving this project by providing software, hardware, communication equipment and satellite bandwidth free of cost. ISRO has extracted a commitment from tertiary hospitals to provide services at nominal charges, enabling people in the remotest parts of India to access super specialty medical care. Presently, ISRO's telemedicine network includes over 300 installations, of which 45 are super specialty hospitals and 10 are mobile units, and benefits over 300,000 patients annually. For example, a patient in Lakshadweep Island in the Indian Ocean, which is 220 nautical miles from the Kerala coast can visit the local Indira Gandhi district hospital and virtually access facilities and interact with the Amrita Institute of Medical Sciences, Kochi in Kerala. It may be mentioned here that various US and other international companies



like Intel, GE, Texas Instruments and Philips and Indian companies like TCS, Wipro and many small and medium entrepreneurs are involved in developing a wide range of instruments, software tools and accessories to accelerate and better facilitate telemedicine activities in India. ISRO satellites are the backbone of this system. This is an area which has huge potential for growth. The

Department of Science and Technology (DST) has also identified the development of medical instrumentation and systems including those enabling telemedicine as one of the major goals in the Eleventh Five Year Plan.

¶14. (U) ISRO has installed specially designed disaster warning receivers in vulnerable coastal areas for direct transmission of warnings against impending disasters like cyclones based on meteorological data from INSAT. ISRO also plans to establish the Indian Regional Navigational Satellite System (IRNSS) using a constellation of seven satellites in the next six to seven years to provide navigation and timing services over the Indian subcontinent. IRNSS would be a key feature of the Indian strategy for establishing an indigenous and independent satellite navigation system.

¶15. (U) The IRS series of imagery satellites - some with resolution better than one meter - provide data for groundwater prospect mapping, crop acreage and production estimation, potential fishing zone forecasting based on chlorophyll-a distribution and sea surface temperature, biodiversity characterization, detailed impact assessment of watershed development projects and generation of natural resources information. In order to ensure that the above information reaches the rural population directly, ISRO has established over 410 Village Resource Centers (VRC) operated with the participation of local Non Government Organizations (NGO).

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Commercial Launch of Satellites

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¶16. (U) ISRO's capability to launch its own satellites has now been expanded to generate additional revenues. ISRO's commercial arm, Antrix Corporation, provides a multitude of services including transponders lease, remote sensing data services, launch services and early-orbit-phase mission support for satellites of other countries. Antrix has registered an annual growth rate of 20 percent in the past few years with revenues of over USD 150 million (INR 6.64 billion) and a profit of about USD 24 million (INR 1.05 billion) in the previous financial year. During the past year, ISRO has successfully launched satellites from Italy, Israel, Korea, Canada, Germany, Japan, Netherlands and Denmark including the orbiting of 10 small satellites in a single launch. ISRO plans to launch over 70 Indian and international satellites during the course of next five years (Reftel-A). This includes launches of satellites for Algeria, France, Singapore and some of the countries mentioned above. Antrix is wanting to expand its market share in remote sensing imageries, infrastructure services in space for broadcasting, and mobile communication and positioning systems.

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Other Initiatives and Future Plans of ISRO

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¶17. (SBU) After the launch of "Chandrayaan I", India is planning to launch in mid 2009 its first dedicated Astronomy Satellite (ASTROSAT). The satellite is expected to conduct multi-wavelength studies of celestial sources and phenomena using a cluster of X-ray astronomy instruments and an ultraviolet imaging telescope. ISRO



also plans to launch a 100kg satellite named 'Aditya' around 2012 to study the dynamic solar corona, the outermost region of the sun. ISRO is also looking at developing and demonstrating capabilities for space recovery technologies, air breathing propulsion systems and possibly a fully autonomous manned space vehicle in about 8-10 years. NASA's Jet Propulsion Laboratory's Director Dr. Charles Elachi visited ISRO on August 20 with the objective of exploring collaborations on planetary missions.

¶18. (SBU) ISRO intends to further develop the GSLV and enhance its capability to launch over 4000kg class communication satellites. Along with the Airport Authority of India (AAI), ISRO is involved in establishing India's satellite based navigation system for aiding civil aviation traffic across the country. The system is called Global positioning satellite-Aided Geosynchronous Augmented Navigation system (Gagan). Many US companies including Raytheon are associated with this project. The US Embassy through the Federal

Aviation Administration (FAA) has been involved in facilitating this project. Finally, ISRO is now actively working towards developing micro, nano and pico satellites. Academic institutions including Indian Institute of Technology (IIT) Kanpur and Anna University, Chennai are building these satellites.

¶19. (U) ISRO is also interested in the Reusable Launch Vehicle (RLV). According to public statements by ISRO Chairman Dr. Madhavan Nair, the RLV would have a first stage with a winged body, which could launch a satellite in orbit and return, and a second stage, which would be like a space capsule that could land either in sea or on land. They are working on the proof of concept which should be ready in two years time; ISRO expects to start work on the RLV project around 2010.

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Constraints Faced by ISRO
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¶20. (SBU) ISRO lost a large number of trained lower and middle level scientists and engineers to 200 Fortune 500 companies that have recently set up operations in India, due in part to the disparity in salary between public and private sectors. While the Sixth Pay Commission report provides public sector scientists a 40-70% pay raise, ISRO still expects difficulty in attracting young scientists with the required technical background and skills. To address this gap, ISRO set up in September, 2007 the Indian Institute of Space Science and Technology at Tiruvanathapuram in Kerala. The Institute, which has admitted more than 140 students, offers high quality education in space science and technology. In addition to obtaining a Bachelors Degree in space technology with specialization in avionics and aerospace engineering or an integrated Masters Degree in applied sciences with special emphasis on space, students can expect complete fee waiver and assured employment after graduation. ISRO also has a program called "RESearch sPONsoreD - RESPOND" to support academic institutions that take up research programs of relevance to ISRO.

¶21. (SBU) Acquisition of advanced or specialized electronic hardware has presented a challenge to ISRO. India has a booming VLSI design environment, but the existing eleven semiconductor fabrication facilities are under the government sector and have at least six- to seven-generation old microelectronic processing technology. There have been some initiatives to create advanced facilities for research under the nanotechnology initiative (Reftel B). Further, due to the new semiconductor policy (Reftel C), some private companies are in the process of establishing advanced



microelectronic processing facility. Dr. Neeraj Saxena, Managing Director of SemIndia, told SciFSN that that they are still in the process of installation and will not be operational until mid 2009 at the earliest. They plan to fabricate integrated circuit chips using 0.09 micron (90nm) technology. Their priorities and schedule may not meet ISRO's immediate requirements. In order to overcome restrictions on the import of advanced electronic components, ISRO has now decided to invest in its own fabrication facility. It recently acquired a state-owned company, Semiconductor Complex Limited (SCL) in Chandigarh. Presently SCL can cater up to 0.8 micron technology. ISRO had attempted to upgrade this facility and had invited proposals from IBM and Atmel from the US. While IBM was selected, ISRO could not provide specific end use certification and wanted to have a flexible facility, catering to its various needs. As a result, IBM could not go ahead with the upgradation. ISRO now plans to proceed with the upgrade on its own while continuing to develop Micro Electro Mechanical Systems (MEMS) based sensor and other application requirements using the existing 0.8 micron technology.

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Comment
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¶22. (U) ISRO has been effective in achieving its program goals, and we expect its successes will continue. To date, ISRO has partnered primarily with Indian companies. However, its ambitious programs and focus on technology advancement suggest that ISRO's needs are not likely to be met by domestic resources. NASA's successful

partnership with ISRO on the "Chandrayaan I" moon mission highlights ISRO's eagerness to collaborate with US partners, both public and private, in pursuit of its goals.  End Comment.

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